ABERRATIN CORRECTED LATTICE IMAGING WITH SUB ANGSTROM RESOLUTION

C. Kisielowski*, E.C. Nelson*, C. Song*, R. Kilaas*, A. Schwartzmann, A. Thust*****

***National Center for Electron Microscopy, One Cyclotron Rd., Berkeley, CA 94720 / USA**
****Brown University, Division of Engineering, 182 Hope Street, Providence, RI 02912 / USA**
***** Institut fuer Festkoerperforschung, Forschungszentrum Juelich, D-52425 / Germany**

In 1999 NCEM's One Angstrom Microscope (OAM) became fully operational. The OAM is a Philips CM300 FEG/UT field emission microscope with holographic capabilities that is equipped with a GATAN Inage Filter (GIF) and operates at 300 kV. It is designed to reach a resolution close to the "magic barrier" around one Angstrom (100 pm) by combining mid-voltage technology with advanced computer processing [1,2]. A hardware correction of the threefold astigmatism allows for aberration free imaging down to sub Angstrom values [3]. In this contribution it will be shown that the instruments performance exceeded expectations because sub Angstrom resolution can be achieved by reconstructing electron exit waves from focal series [4].

Fig.1a depicts a simulated [110] lattice image of a 90^0 partial dislocation in silicon. Tersoff potentials were used to calculate the exact atomic positions around dislocations with different core structures [5]. Multi-slice calculations generated the lattice images. They exhibit complicated interference patterns because the OAM's contrast transfer function (CTF) oscillates rabidly with increasing scattering vectors. However, the simplicity of the underlying crystalline structure can be recovered by reconstructing the electron exit wave from series of 10-20 lattice images [4] as shown in figures 1b and 1c. It is seen that a resolution well below 136 pm should be achievable with the OAM and one would recognize different core reconstructions. Experimentally, a shuffle set dislocation in GaAs was already imaged by this method with a resolution that must be better than 141 pm. [6].

Performance tests of the OAM confirm information transfer to values around 90 pm. Therefore, the 89 pm spacing of the (004) reflections in diamond [110] should be exploitable to resolve dumbbells in diamond. Figure 2 shows two [110] lattice images and their Fourier transform that are part of a focal series. A strong (004) reflection can be observed only if images were underfocused by 170 pm or more. This agrees with the expectation that the CTF envelope extends to larger scattering vectors with increasing underfocus. In this case the CTF tail reaches 1 / d(004) = $11.2\ nm^{-1}$ at an underfocus of 170 nm. 15 lattice images from a focal series were used to reconstruct the electron exit wave by means of the Philips/Brite Euram reconstruction software. The dumbbell structure at a spacing of exactly 89 pm is resolved in the phase image shown in figure 3. The result indicates that the information limit of the OAM must be below this value.

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